Final Technical Report

Analysis of IUE Spectra of Comets
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We have carried out a continuing program to analyze the archival spectra of comets that were obtained over the 17 years of operation of this remarkably productive satellite. During the years of this grant, many results were published while additional work is still going on without support from the IUE project.

Highlights of our analyses have been provided in various progress reports and we therefore emphasize here the results since the last progress report. Toward the end of the grant we emphasized two projects, an analysis of the atomic sulfur lines in the SWP spectra and an analysis of the secular variation in activity of periodic comets that were observed at multiple apparitions.

The atomic sulfur triplet at 1812 Angstroms has long been known to be optically thick and work by E. Roettger (not supported here) represented the first attempt to use the sulfur lines, allowing for the optical depth, to estimate the total abundance of sulfur. She showed that the sulfur could not be accounted for by the CS also observed in IUE spectra and estimated the amount of H_2S (newly discovered at that time) would be required to explain the observed S. We subsequently realized that her model for the radiative transfer of the sulfur triplet was inadequate and R. Meier and the PI have developed an entirely new model of the radiative transfer. We have also redetermined the sulfur abundances for all IUE spectra with sufficient signal-to-noise ratio. We find, in fact, that even more sulfur is needed than can be explained by the typically observed amounts of H_2S. This led us to predict the existence of a significant amount of OCS which we have now detected in comet Hyakutake. These results have been written up and accepted for publication in *Icarus*. A preprint is appended.

Several short-period comets have been observed with IUE at two apparitions and comet Encke has been observed at four apparitions. In a very few cases, observations at different apparitions were obtained at essentially the same point in the comet's orbit. In these cases, we can carry out a sensitive test for secular variation in the comet. We have found that the comets differ dramatically among themselves. We have set very tight upper limits on the secular variation of Encke, less than a few percent per apparition. Comet P/Tempel 2, on the other hand, exhibited a factor two variation from one apparition to the next. These results have been written up as a draft manuscript (copy appended) which we expect to submit to *Icarus* during the summer of this year.

Other problems investigated under this grant, and typically mentioned in previous progress reports, include other aspects of the sulfur chemistry in comets,

both extended analyses of the diatomic sulfur seen only (until this year) in comet IRAS-Araki-Alcock and the derivation of very low upper limits on the fractional abundance of SO and SO_2, a result that severely constrains the mechanism for the production of S_2. We attempted to study SH as well but found that the only realistic test of the model we developed for SH involved ground-based spectra. We studied the heliocentric light curve of comet d'Arrest and compared the results with optical data.

Some other projects were started but not completed. We still hope to complete some of them despite the lack of funding. The most notable of these is the extraction of CO abundances and limits thereon for estimating CO/H_2O ratios in many comets.

A set of relevant reprints is included as an appendix to this report to provide additional details.

Publications

Haken et al. 1996. Secular Variation of Activity in comets 2P/Encke and 9P/Tempel 1. To be submitted to *Icarus*,

Meier, R. and M. F. A'Hearn 1996. Atomic Sulfur in Cometary Comae Based on the UV Spectra of the S I triplet near 1814 Å. *Icarus*, in press.

Kim, S. J. and M. F. A'Hearn 1992. g-Factors of the SH (0-0) Band and SH Upper Limit in Comet P/Brorsen-Metcalf (1980o). *Icarus*, 97, 303-306.

Kim, S. J. and M. F. A'Hearn 1991. Upper Limits of SO and SO_2 in Comets. *Icarus*, 90, 79-95.

Kim, S. J., M. F. A'Hearn, and S. M. Larson 1990. Multi-Cycle Fluorescence: Application to S_2 in Comet IRAS-Araki-Alcock (1983d). *Icarus*, 87, 440-451.

Festou, M. C., P. D. Feldman, and M. F. A'Hearn 1992. The Gas Production Rate of Comet d'Arrest. In "Asteroids, Comets, Meteors 1991" (Houston TX, Lunar & Planetary Institute), 177-186.